

# **Health & Safety Manual**

## **Supplement 33.03**

### **Exposure to Radiation in an Emergency**

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# Exposure to Radiation in an Emergency

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## **Exposure to Radiation in an Emergency**

### **1.0 Introduction**

Supplement 33.02 (Occupational Radiation Protection—Implementation of 10 CFR 835) of the *Health & Safety Manual* contains the Department of Energy (DOE) dose limits for routine occupational exposure, along with provisions for higher emergency doses in cases where there is no practical or reasonable alternative and where the exposure will save human life, minimize significant exposure to others, or protect major property. (“Major property” is typically valued in excess of \$100,000 and may include data and information.) In all cases, the dose must be justified by the importance of the emergency task to be performed.

This supplement provides implementing guidance and information for individuals who may have to direct an emergency response and authorize radiation doses in excess of 5 rem per person. It also

- Provides guidance on responding to the emergency and assessing potential radiation doses.
- Describes the potential biological effect from such doses.
- Specifies the activities and conditions under which emergency doses may be authorized.
- Specifies who may authorize emergency doses and the level of Hazards Control concurrence required.

### **2.0 Applicability**

The requirements and guidelines in this supplement apply to anyone responding to an off-normal or emergency condition where radiation doses may exceed the routine occupational dose limits.

### **3.0 Requirements/Regulatory Summary**

*Code of Federal Regulation*, Title 10, Part 835, provides dose limits for individuals responding to emergency situations; these limits are shown in Table 1 of this supplement. Any facility-specific procedures for emergency re-entry and rescue shall be consistent with these limits and shall be reviewed by the ES&H team.

**Table 1. Guidelines for authorizing individual emergency doses.**

<b>Whole-body dose limit (rem)<sup>1-3</sup></b>	<b>Activity</b>	<b>Condition</b>	<b>Minimum authorization level<sup>4</sup></b>	<b>Minimum concurrence level</b>
<b>5</b>	<b>All</b>	<b>Any emergency</b>	<b>Person receiving the dose</b>	<b>—</b>
<b>10</b>	<b>Lifesaving, or protection of large populations, or protection of major property</b>	<b>Only on a voluntary basis to someone who</b> <ul style="list-style-type: none"> <li>• <b>Has completed Radiological Worker Training, and</b></li> <li>• <b>Has been briefed about the hazards, and</b></li> <li>• <b>Does not have a medical condition that would be adversely affected by the emergency response.</b></li> </ul>	<b>Incident Commander or senior facility person</b>	<b>Health and safety technician</b>
<b>25</b>	<b>Lifesaving or protection of large populations</b>	<b>Only on a voluntary basis to someone who</b> <ul style="list-style-type: none"> <li>• <b>Has completed Radiological Worker Training, and</b></li> <li>• <b>Has been briefed about the hazards, and</b></li> <li>• <b>Does not have a medical condition that would be adversely affected by the emergency response.</b></li> </ul>	<b>Incident Commander or senior facility person</b>	<b>Health physicist or ES&amp;H team leader</b>
<b>&gt;25</b>	<b>Lifesaving or protection of large populations</b>	<b>Only on a voluntary basis to individuals fully aware of the risks involved.</b>	<b>Incident Commander or senior facility person</b>	<b>Health physicist or ES&amp;H team leader</b>

<sup>1</sup>The dose limit is allowed only if lower dose limits are not practicable.

<sup>2</sup>The dose limit to the lens of the eye is 3 times the listed values.

<sup>3</sup>The dose limit to the skin of the whole body and the extremities is 10 times the listed values.

<sup>4</sup>The Incident Commander has legal authority to act autonomously and therefore does not need to obtain concurrence of the health physicist or ES&H team leader before authorizing emergency doses >5 rem.

## **4.0 Controlling Exposure to Radiation in an Emergency**

### **4.1 Responding to the Emergency**

During an emergency, the senior facility person present (i.e., the individual with the highest level of authority) shall direct the emergency response until relieved by the Fire Department Incident Commander (IC). Thereafter, the senior facility person acts as a resource to the IC. Throughout the emergency, the ES&H team acts as a resource to the person directing the emergency response (i.e., the IC or senior facility person.)

The person directing the emergency response must

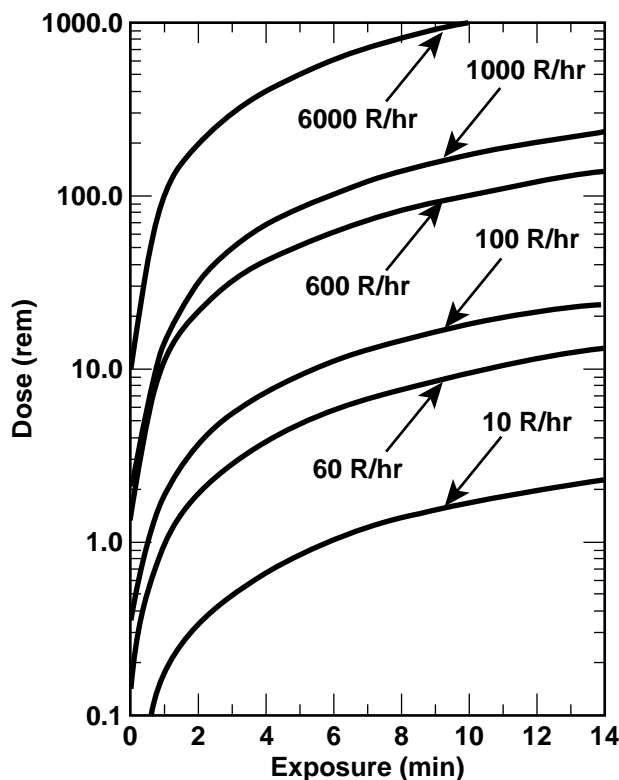
- Identify tasks critical to the emergency response. These may include
  - Saving lives.
  - Protecting major property.
  - Protecting large populations.
  - Securing critical equipment.
  - Rectifying conditions that could otherwise escalate and cause unacceptable injury or impact.

Facility workers present at the time of the emergency are an excellent resource for identifying critical tasks.

- Weigh the importance of the tasks against the actual and potential risks to which rescue personnel will be exposed. Use the emergency dose guidelines in Table 1 to determine the maximum dose allowed for various types of operations.
- Establish boundaries delineating hazardous zones. Ask the facility health and safety technician or health physicist to determine the radiation dose rates and, where possible, the concentrations of airborne radioactive material in areas where emergency operations need to occur.
- Regulate the movement of personnel across those boundaries. Hazards Control's Emergency Assistance (EA) Team can be requested through the Fire Department, and can provide access control.

Once the decision has been made to re-enter an affected area

- Establish the exposure time limit for the response. Figure 1 shows the integrated dose as a function of the dose rate and exposure time. The health physicist or, in his/her absence, the health and safety technician can assist in calculating stay times.
- Develop an operating schedule for tasks in areas where responders could receive individual doses >5 rem.



**Figure 1. Guide for determining the dose and exposure time during an emergency. Assume that an exposure of 1 R will produce a dose of 1 rem.**

- Establish a contingency plan in case the working area conditions are significantly different from those anticipated or if the tasks cannot be accomplished.
- Ask for volunteers for any tasks that may result in individual doses >5 rem.

**IMPORTANT.** *Code of Federal Regulation*, Title 10, Part 835 requires that any emergency responder who may receive more than 5 rem must be a volunteer who has completed Radiological Worker Training, has been briefed about the hazards involved, and is fully aware of the risks involved if he/she is to receive a dose >25 rem. Furthermore, LLNL's policy is to avoid using volunteers with known medical conditions (e.g., pregnancy, heart condition) that might be negatively impacted by the response.

- Assign specific tasks to volunteers.
- Supervise the exposure time of those entering areas where individual doses >5 rem might be received.

## 4.2 Biological Effects of High Doses of Radiation

The assumed risk associated with chronic, low-level occupational radiation dose is an increased risk of cancer; the known risks associated with acute, high-level radiation doses can include radiation sickness and death. Table 2 on the following page provides a summary of the health effects associated with various levels of acute whole-body doses. Similar doses to an extremity (e.g., the hand, forearm, or foot) or to a small part of the body (e.g., the throat, chest, or intestines) will result in less severe symptoms and a concurrent decrease in the mortality rate.

## 4.3 Errors in Estimating Dose

Radiation dose-rate information obtained during an emergency is generally not as accurate as information obtained under more ideal conditions because

- There may be significant fluctuations in the actual dose rate.
- The dose rate may not be uniform from one area to another.
- There is generally not enough time to conduct a thorough survey.
- The accuracy of dose-rate measurements are limited by the accuracy of the instrument used to measure the dose.

Therefore, when calculating stay times based on dose rate measurements, assume the measurement is low by at *least* 20%. If possible, assume it is low by 50 to 100%.

## 4.4 Authorizing Emergency Doses

From both an injury and a radiation dose standpoint, the decision to rescue a person from a high-radiation field should be made promptly to maximize the injured person's chance of survival. Rescue may only be authorized if

- It is possible to estimate the dose to responding personnel.
- The dose can be justified by the activity to be performed.
- The risk of injury to those individuals involved in the rescue and recovery operations is minimized.

For lifesaving operations, consider the dose the victim has already received and the dose he/she may be still receiving. For example, if a victim has already received more than 800 rads, there is little chance of saving his/her life and therefore little point in exposing emergency responders to doses >25 rem.

Note that emergency doses should NOT be authorized to recover the body of a deceased person. This type of recovery should be made under more planned conditions.

**Table 2. Biological effect from acute whole-body doses.<sup>1</sup>**

<b>Dose range (rads)<sup>2</sup></b>	<b>Biological effect</b>	<b>Survival<sup>3</sup></b>
<b>50–100</b>	<b>Slight decrease in blood count; minor radiation sickness</b>	<b>Virtually certain</b>
<b>100–200</b>	<b>Symptoms of bone marrow damage; moderate radiation sickness</b>	<b>Probable (&gt;90%)</b>
<b>200–300</b>	<b>Moderate to severe bone marrow damage; serious radiation sickness</b>	<b>Possible— Bottom of third range: LD<sub>5</sub>/60; Middle third: LD<sub>10</sub>/60; Top third: LD<sub>50</sub>/60</b>
<b>350–550</b>	<b>Severe bone marrow damage; extreme radiation sickness</b>	<b>Death within 3 1/2–6 weeks Bottom half of range: LD<sub>90</sub>/60; Top half: LD<sub>99</sub>/60</b>
<b>550–750</b>	<b>Severe bone marrow damage; moderate intestinal damage; extreme radiation sickness</b>	<b>Death within 2–3 weeks</b>
<b>750–1000</b>	<b>Combined gastrointestinal and bone marrow damage; extreme radiation sickness</b>	<b>Death within 1–2 1/2 weeks</b>
<b>1000–2000</b>	<b>Gastrointestinal damage; early transient incapacitation; gastrointestinal death</b>	<b>Death 5–12 days</b>
<b>2000–3000</b>	<b>Gastrointestinal and cardiovascular damage</b>	<b>Death within 2–5 days</b>

<sup>1</sup>James J. Conklin and Richard I. Walker Eds., *Military Radiation* (Academic Press Inc., New York, 1987), pp. 165–190.

<sup>2</sup>For acute effects, doses are measured in rads. Routine occupational dose (formally referred to as “dose equivalent” and measured in “rem”) is the product of the dose delivered (measured in rads) and the radiation weighting factor of the radiation delivering the dose. The radiation weighting factor is 1 for beta and gamma radiation, 20 for internally deposited alpha radiation, and varies between 1 and 11 for neutron radiation, depending on the energy of the radiation. Routine internal doses are calculated by assessing how much dose the person will receive over the next 50 years as a result of the uptake, and are recorded in “rem” as “committed effective dose equivalents.”

Radiation weighting factors should NOT be applied to acute doses in excess of 25 rads, as the body’s normal repair mechanisms may not function normally when dealing with large doses, and because non-stochastic effects (i.e., those due to cell killing) usually override the deterministic effects (i.e., those associated with an increased risk of cancer.) Similarly, the “50-year dose” is also not appropriately used to assess the acute consequence of an internal exposure.

<sup>3</sup>LD<sub>x/y</sub> = Lethal dose to “x” % of the population within “y” days of receiving the dose.

The decision to authorize a dose to emergency responders to avert additional onsite or offsite doses may also be difficult, largely because the magnitude of the dose already received and the potential dose averted will likely be unknown. The amount of dose authorized to avert additional onsite or offsite doses should commensurate with the potential for averting *additional* doses, taking into account the magnitude of dose already received by the population. For example, it may make sense to authorize a 10-rem dose to an emergency responder to avert a collective 10-rem offsite dose. On the other hand, it may not make sense to authorize the same dose if the population has already received a dose of 100 rem.

As a general guideline, when acting to “protect large populations,” the *collective* dose emergency responders receive as a result of a planned action should not exceed the collective dose they are averting by that action. For example, if the response will likely result in a collective dose of 20 rem to responders, but will only avert a collective dose of 1 rem to the population, the exposure is not warranted. However, if a 20-rem dose to responders will avert a collective dose of more than 100 rem, then the exposure might be warranted.

The level of concurrence needed to authorize emergency doses depends on the level of dose that may be received. Refer to Table 1 for guidelines on authorizing emergency doses.

## 4.5 Summary

Individuals directing a response to emergency situations involving radiation should remember that

- Large measurement errors may be associated with field measurements of high-radiation dose rates.
- High-radiation doses can cause serious illness and death (see Table 2 for details.)
- Doses >5 rem may only be authorized by specific individuals and must have the concurrence of Hazards Control (see Table 1 for details.)
- Individuals who may receive >5 rem in an emergency response must be volunteers, must have completed Radiological Worker Training, and must be briefed about the risks involved.
- Doses >25 rem are only authorized to save a human life or to protect large populations. Volunteers must be fully aware of the risks involved.

## **5.0 LLNL Contacts**

For more detailed information on the issues discussed in this supplement, refer to the local self-help plans or facility safety procedures (FSP) or contact the following as necessary:

- Your supervisor.
- The facility or off-shift health and safety technician.
- The ES&H Team Leader.
- The ES&H team health physicist.
- Hazards Control Health Physics Technical Leader (ext. 2-5172).

## **6.0 References and Supporting Standards**

*Code of Federal Regulations*, Title 10, Part 835, “Occupational Radiation Protection Implementation Guides.”

James J. Conklin and Richard I. Walker Eds., *Military Radiology* (Academic Press Inc., New York, 1987), pp. 165–190.